Atomic Energy Control Board
P.O. Box 1046
Ottawa, Canada
K1P 5S9

Commission de contrôle de l'énergie atomique
C.P. 1046
Ottawa, Canada
K1P 5S9

INFO-0204

WHOLE-BODY COUNTERS IN CANADA

by

C. Létourneau

Atomic Energy Control Board
Ottawa, Canada

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Canada

Report

ABSTRACT

A compilation of whole-body counting existing across Canada was prepared by AECB staff. This work was initiated so that AECB staff and other concerned parties would have this information readily available, especially during urgent situations. This report is to be used for reference purposes only, as it makes no attempt to judge the present state of the art of whole-body counting.

RÉSUMÉ

Une compilation des anthroporadiamètres existant à travers le Canada a été effectuée par le personnel de la CCEA. Ce travail a été entamé pour que le personnel de la CCEA et toutes autres personnes intéressées aient cette information à portée accessible, surtout lors de situations urgentes. Le présent rapport doit être utilisé à des fins de réference seulement car aucun jugement de l'état d'art actuel de l'opération des anthroporadiamètres n'a été établi.

TABLE OF CONTENTS

Introduction

1. Location of Whole-Body Counters in Canada
2. Techniques and Detectors for Whole-Body Counting in Canada
3. Measurements of Radionuclides
4. Frequency of Use of Whole-Body Counters in Canada

Appendix A: Data sheets on whole-body counters provided by respondents

INTRODUCTION

This report provides a current listing of whole-body counters in Canada, based on a questionnaire sent out to various organizations during 1986. It was prepared to ensure that AECB staff and other concerned parties would have such information readily available and should be used for reference purposes only. No attempt was made to judge trends or to make recommendations on whole-body counting.

Present Status

There is an increasing demand for direct measurement of internal uptake of radionuclides accumulated by humans. Whole-body counters can measure the gamma rays emitted by some radionuclides and, thus, measurements of the activity lodged inside the body can be obtained from outside by *in vivo* counting.

Whole-body radioactivity monitors capable of measuring low activity levels are costly. A great deal of laboratory space is also needed. For these reasons, whole-body counters are not numerous. The survey showed that, in Canada, most of the whole-body counters are located in the eastern provinces and are found mainly at nuclear facilities.

Whole-body counters are used for clinical and research purposes, but the main use is for measuring occupationally-exposed persons in the nuclear industry. Natural and man-made radionuclides are measured in workers and, on occasion, in members of the public. Some use of whole-body counters, although to a lesser extent, is directed to non-clinical applications such as research on subject background and whole-body techniques, metabolic studies, and environmental measurements. Such research activities are carried out, amongst others, at the Bureau of Radiation and Medical Devices (Health and Welfare), the Cancer Treatment Foundation, the Atomic Energy of Canada Limited research institutions, and at McMaster University.

About This Document

For the general user, this document gives the type of whole-body counter, its location, its main uses, and the telephone number of the facility. For the expert in the field, additional technical information can be found in Appendix A.

I wish to thank all those experts who helped bring our information up to date by spending their valuable time in answering the questionnaire. After reading this report, the reader is welcomed to direct any additional information or comments to the Radiation Protection Division of the Atomic Energy Control Board (Box 1046, Ottawa, Ontario, K1L 5S9).

1. Location of Whole-Body Counters in Canada

Fourteen locations were found having a whole-body counter. Ten of these are outlined in Table 1 (data were unavailable from Monserco, the University of

Western Ontario, Helgeson Nuclear Services, and the Radiation Management Corporation. The latter two are U.S. companies that provide counting services with their mobile unit to Canadian clients). Out of the fourteen sources, 6 were associated with nuclear facilities, 2 with medical institutions, 1 with government, and 3 with service companies.

Most whole-body counters are located in Ontario owing to the importance of the nuclear industry there. In New Brunswick and Québec, whole-body counters are found at the Point Lepreau and Gentilly Nuclear Generating Stations. The only western province where whole-body counters can be found is Manitoba: at the AECL laboratories in Pinawa and at the Cancer Treatment Foundation in Winnipeg. No plans to purchase a whole-body counter are known to exist in the other western provinces.

Additional purchases across Canada are not anticipated. Changes will come mainly from improving the present units in order to increase sensitivity and resolution so that this costly equipment may be used to its fullest potential.

2. Techniques and Detectors Used for Whole-Body Counting in Canada

There are several techniques used world-wide[1] for whole-body counting. These include: arc, chair, arc-reclining chair, linear scanning, complex-motion scanning, stretcher, planar large detector, partially-enveloping large detector, and four large detector techniques. The trend shows a lessening of interest in chair geometries and an increasing interest in scanning techniques which offer greater flexibility and good results with modestly-sized crystals. In Canada, techniques vary little, and the linear scanning and stretcher techniques are the most popular (Table 2). The chair technique is used at the Point Lepreau Nuclear Generating Station and at AECL Whiteshell Research Establishment.

The type of detectors used for whole-body counting also vary. The most widely used in Canada is the NaI (Tl) crystal detector. The number of crystals used varies with each laboratory's needs; in Canada, the number of crystals may vary from 1 (most laboratories) to 5 (BRMD). Another type of detector that Hydro-Québec and BRMD are planning to use is the hyperpure germanium detector; the high cost of this detector is seemingly justified by the better resolution achieved, although some sensitivity may be lost.

3. Measurement of Radionuclides

Table 3a lists the various radionuclides (with lower limits of detection and accuracy of measurements) which are routinely measured. Organizations are concerned with radionuclides specific to the nature of their function. For example, uranium industries (mines, mills, and refineries) are mostly preoccupied with the burden of uranium in the worker, nuclear generating stations with fission and activation products, hospitals with radiopharmaceuticals.

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[1] IAEA, 1970. Directory of Whole-Body Radioactivity Monitors. International Atomic Energy Agency, STI/PUB/213, Vienna.

Measurements must take into account the subject background. To do so, several methods can be used depending on site-specific conditions. For instance, one can:

a) subtract previous measurements made on uncontaminated subjects (this is possible only in regular monitoring programs);

b) measure background of phantoms (see further in text);

c) use a backscatter standard (usually K-40).

Measurements must also be submitted to quality assurance. The calibration of whole-body counters requires the use of reference standards. This is accomplished by the use of a phantom containing known quantities of radionuclides. A key aspect of in vivo assay is the need for a realistic phantom that reproducibly simulates the counting geometry of the internally-deposited radionuclides. The success of the phantom depends on how faithfully it simulates human morphology, radiation absorptions, and scattering in tissues. The more realistic the phantom, the better the calibration, the more precise the measurements (it is pointed out, however, that greater uncertainties are associated with assumptions used for dose estimates such as radionuclide retention). Most phantoms in Canada (Table 3b) are polyethylene bottles filled with KCl and tend to be system-specific.

BRMD (Health and Welfare) uses several phantoms, the most sophisticated being the Livermore Lab Realistic Thorax. This phantom is available to other laboratories across Canada. In 1982, the AECB formally recognized RPB (Now BRMD) as the national reference centre for these measurements, and the program is in the process of being expanded. The present services include phantoms for whole-body counting measurements for medium- to high-energy gamma emitters, thorax measurements for uranium and thorium, and thyroid measurements for I-125. The proposed expansion will include fabrication of a number of secondary standard phantoms for thyroid measurements. Lung inserts for the thorax phantom containing plutonium and americium will be fabricated or purchased. Also, an adjustable phantom for calibrations at medium and high energies for different body sizes will be obtained. The intercomparison program will also be expanded.

4. Frequency of Use of Whole-Body Counters in Canada

The length of counting depends on the whole-body counter, on the type of contamination (fission and activation products taking less time than transuranics), and on the purpose of the test. Usually, the first test is done for routine purposes and takes 10 minutes. If any deviation from the normal spectrum occurs, a longer test is performed (this can prove to be unnerving for some subjects and anticlaustrophobial measures are usually available). The survey showed that counting is done from 2 or 3 times a week up to several times a day (Table 4).

Table 1. Location of whole-body counters in Canada

Location	Head of the Lab. Expert in Charge	Address	Telephone Number
LP- New Brunswick Electric Power Commission (Point Lepreau)	E. Becker J. O'Donnell	Point Lepreau nuclear generating station Health Physics P.O. box 10 Lepreau, New Brunswick E0G 2H0	(506)659-2102
HQ- Hydro-Québec (Gentilly-2)	R. Fortin L. Crête	Centrale nucléaire de Gentilly-2 Hydro-Québec CP 360,Gentilly P. Québec,G0X 1G0	(819)298-2943
OH- Ontario Hydro (Pickering)	G. Pilar M. Pope	Pickering nuclear generating station, Ontario Hydro Safety Services Department 757 McKay Road Pickering, Ontario	(416)683-7516
HW- National Health and Welfare (Ottawa)	E. Létourneau M. Limson-Zamora	BRMD Human monitoring laboratory National Health and Welfare 775 Brookfield Road Ottawa, Ontario, K1A1C1	(613)998-1196
CR- Atomic Energy of Canada (Chalk River)	J. Johnson G. Kramer/Johnson	Biomedical Research Branch Chalk River Nuclear Laboratories Atomic Energy of Canada, LTD Chalk River, Ontario K0J 1J0	(613)584-3311
Mc- McMaster University (Hamilton)	E. Garnett C. Webber	Department of Nuclear Medecine McMaster University Medical Center Hamilton, Ontario L8N 3Z5	(416)522-4971
EL- Eldorado Resources	H. Carisse S. Allen	Eldorado Resources LTD 1 Eldorado Place Port Hope, Ontario	(416)885-4511
TG- Toronto General Hospital	J. Hamison S. Krishnan	Medical Physics Laboratory Room CCRW-G-803 Toronto General Hospital 200 Elizabeth street Toronto, Ontario, M5G 2C4	(416)595-4048
WR- Atomic Energy of Canada (Pinawa)	A. Petkau S. Pleskach	Whiteshell Nuclear Research Establishment Atomic Energy of Canada, LTD Pinawa, Manitoba, R0E 1G0	(204)753-2311
CT- Cancer Treatment Foundation	W. Huda R. Palser	Cancer Treatment Foundation 100 Olivia Street Winnipeg, Manitoba R3E 0V9	(204)787-2197

Table 2. Techniques and detectors used for whole-body counting in Canada

Location	Chair Technique	Arc Technique	Linear Scanning Technique	Stretcher Technique
LP	3 NaI(Tl) detectors (Lungs, gut, thyroid)			
HQ			1 NaI(Tl) detector 2 Germanium detectors	
OH			1 NaI (Tl) detector	
CR			1 NaI(Tl) detector	
HW				1st chamber: 2 Phoswich /4 Ge 2nd chamber: 5 NaI (Tl)
Mc			1 NaI(Tl) detector	
EL				4 Phoswich
TG				4 NaI(Tl) detectors
WR	1 NaI(Tl) detector	1 NaI(Tl) detector	3 NaI(Tl) detectors	2 Phoswich detectors
CT			2 NaI (Tl) detectors	

Table 3a. Minimal detectable activity and accuracy

Location	Radionuclides	Minimal detectable activity (kBq)			Accuracy
		Lower torso	Lungs	Thyroid.	
LP	Ce-144	5,3	3,1	N/A	
	Cr-51	3,5	2,0	N/A	
	Ba-140	1,0	0,7	N/A	
	Cs-137	0,3	0,2	N/A	
	Zr-95	0,4	0,3	N/A	
	Cs-134	0,3	0,2	N/A	
	Co-58	0,2	0,1	N/A	
	Mn-54	0,2	0,1	N/A	
	Fe-59	0,4	0,3	N/A	
	Zn-65	0,5	0,3	N/A	
	Co-60	0,2	0,1	N/A	
	I-133	N/A	N/A	0,02	
	I-131	N/A	N/A	0,02	
HQ	Cs-137	det. 1 = 0,1			det. 1 = 25%
		det. 2 = 0,7			det. 2 = 10%
OH	Zr-95		0,08		Cs-137 at 4 kBq: 3%
	Ba-140		0,11		Co-60 at 2-4 kBq: 5%
	Co-60		0,15		K-40 at 4 kBq; 23%
	Cs-137		0,22		
	Cs-134		0,18		
	I-131		0,25		
	Zn-65		0,30		
	Ru-106		0,92		
	Ce-144		2,4		
nW	Cs-137		0,02		10%
	K-40		5 g		4%
	natural uranium		3 mg		10%
CR	I-131		0,03		
	Cs-137		0,03		
	Co-60		0,04		
Mc	K-40		—		6%
	U-238		6 mg		—
EL	U-235		5 mg		5 - 15%
	U(U-238/Th-234)		3 mg		5 - 15%
TG	K-40; Tc-99m; I-125; Th		0,04 to 0,2		4%
WR	Cs-137		0,03		
	K-40		—		2,8%
—	Tc-99m; I-131; Ga-67;		0,6		10 - 20%

Table 3b. Type of phantom used for calibration

Location	Type of phantom used
LP	Applied physical technology model BP-615
HQ	70 L polyethylene phantom
OH	Grey and Marten water filled polyethylene
HW	1) Lawrence Livermore Lab Realistic thorax 2) BOMAB 3) open box
CR	Bottle and others
Mc	KCl - water filled bottles
EL	Remcal; and yearly calibrated by BRMD (HW)
TG	Flat bed of KCl
WR	Remcal
CT	Geometric mean

Table 4. Length of counting period, frequency of use of whole-body counter and anti-claustrophobial measures

Location	Length of counting period	Frequency of use	Anti-claustrophobic measures
LP	5 min.	once a year or several times a day	not required
HQ	10 min.	10 people/ day	radio; door kept open
OH	6 - 7 min.	annually to several times a day	intercom; close-circuit T.V.; door may be kept open
HW	15 - 60 min.	variable. up to 6 subjects a day	radio; intercom; 2 feet thick water-filled window
CR	20 min.	8-10 people/ day	
Mc	40 min.	2-3 subjects/ week	music
EL	30 min.	daily (routine monitoring)	not required
TG	various	4 h / day	lights; music; intercom; window; ventilation
WR	25 min.	daily	intercom; music
CT	--	2-3 people/ day	not required

APPENDIX A

Data sheets on whole-body counters
provided by respondents

Data Sheet

1. General

1.4	Laboratory	Point Lepreau Generating Station Health Phys
1.5	Address & Telephone Number	P.O. Box 10, Lepreau, N.B. E0G 2H0 659-2102
1.6	Head of Laboratory	E. Becker
1.7	Expert in Charge	Jim O'Donnell
1.8	Main Uses	Humans (Artificial Activity)

2. Methods

2.1	Technique	
2.2	Geometries	Three Detector Chair

3. Monitoring Room

3.1	Location	Second Floor
3.2a	Portable or Fixed	Fixed
3.3	Approximate Inside Dimensions (cm)	300 x 400
3.4	Inner Shielding	
.1	Material	
.3	Source of Material	
.4	Thickness	
.7	Inside Finish	
.8	Entrance Type	NONE
3.5	Outer Shielding	None (other than the building itself)
3.6	Ventilation System (yes or no)	Yes
3.7	Heating/Cooling System (yes or no)	Yes
3.8	Anti-claustrophobial Measures	None

4. Detectors

4.1	Detector Type	NaI(Tl)
4.2	Detector Number	3
4.3	Shape/Volume	5" dia by 4"thick; 4" dia by 4" thick; 1½" dia by 2" thick
4.4	Shielding	minimum 1" virgin lead for small detector, 4" for large
4.5	Position of Detector	Gut, Lung, Thyroid

5. Basic Ancillary Equipment

5.4 Analyser

Series Number	
Number of Channels	4096
Manufacturer	ORTEC
Model	Model 7010
Type	

5.5 Read-out Units

Unit Type (Chart Recorder or Computer Screen)	Computer
Manufacturer	Hewlett Packard
Model Code	9845B

6.0 Illustrations (Optional)

7.0 Calibration Data
(See Annexed Sheet)

8.0 Minimal Detectable Activity
(Specify Radionuclides and Units) See attached sheet

9.0 Accuracy (% Error) Depends on activity

10.0 Type of Phathom used for Calibration Applied Physical Technology Model BP-615

11.0 Time Period of Examination (Minutes) 5 minutes

12.0 Frequency of Use once/year for exposed personnel

13.0 Estimated Cost of Whole Body Counter $50,000 U.S. in 1978

14.0 Additional Comments

Signature

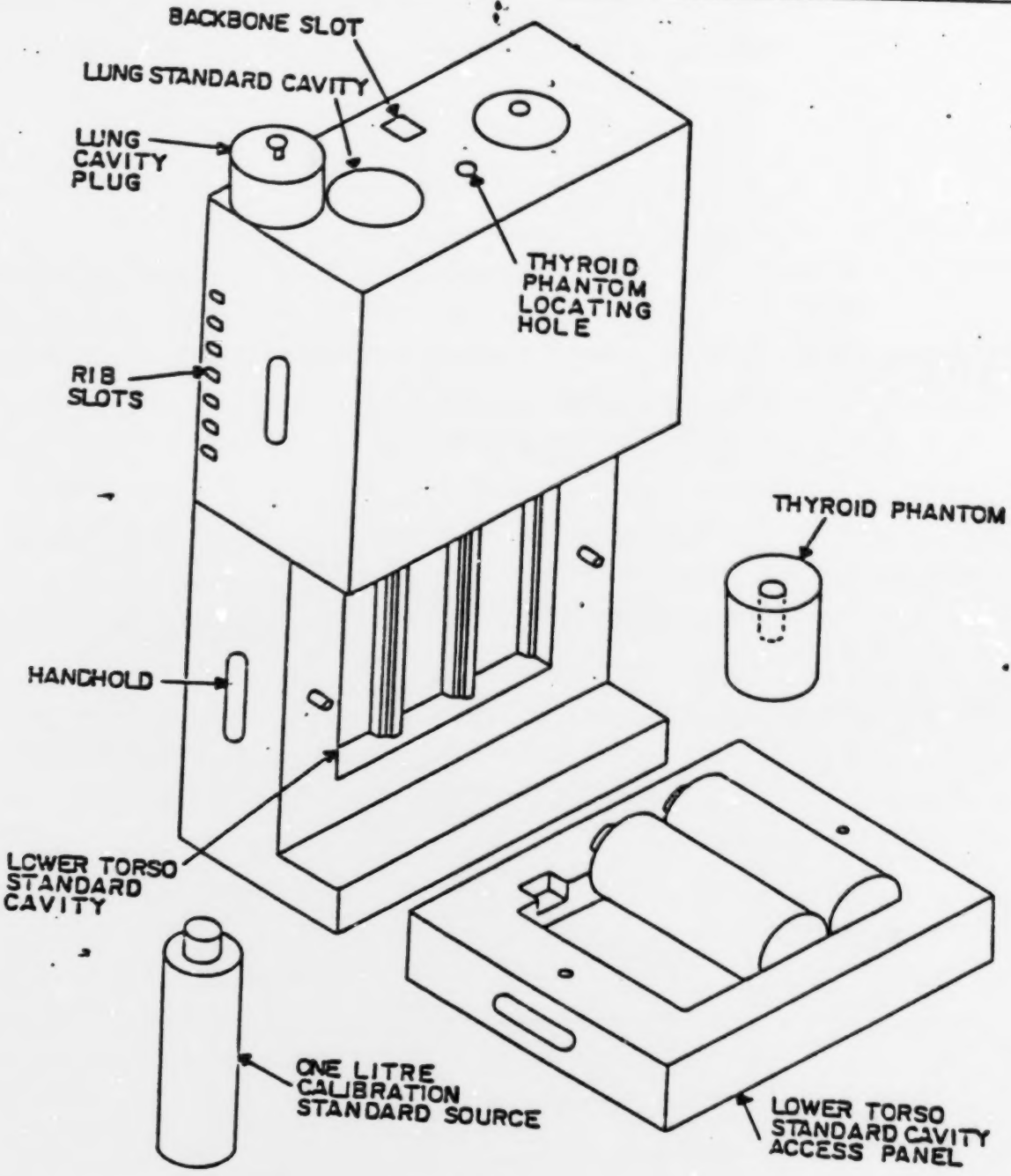


FIGURE 2 APT MODEL BP-615 BODY PHANTOM

TITLE:
BODY COUNTER - PROGRAM DESCRIPTION

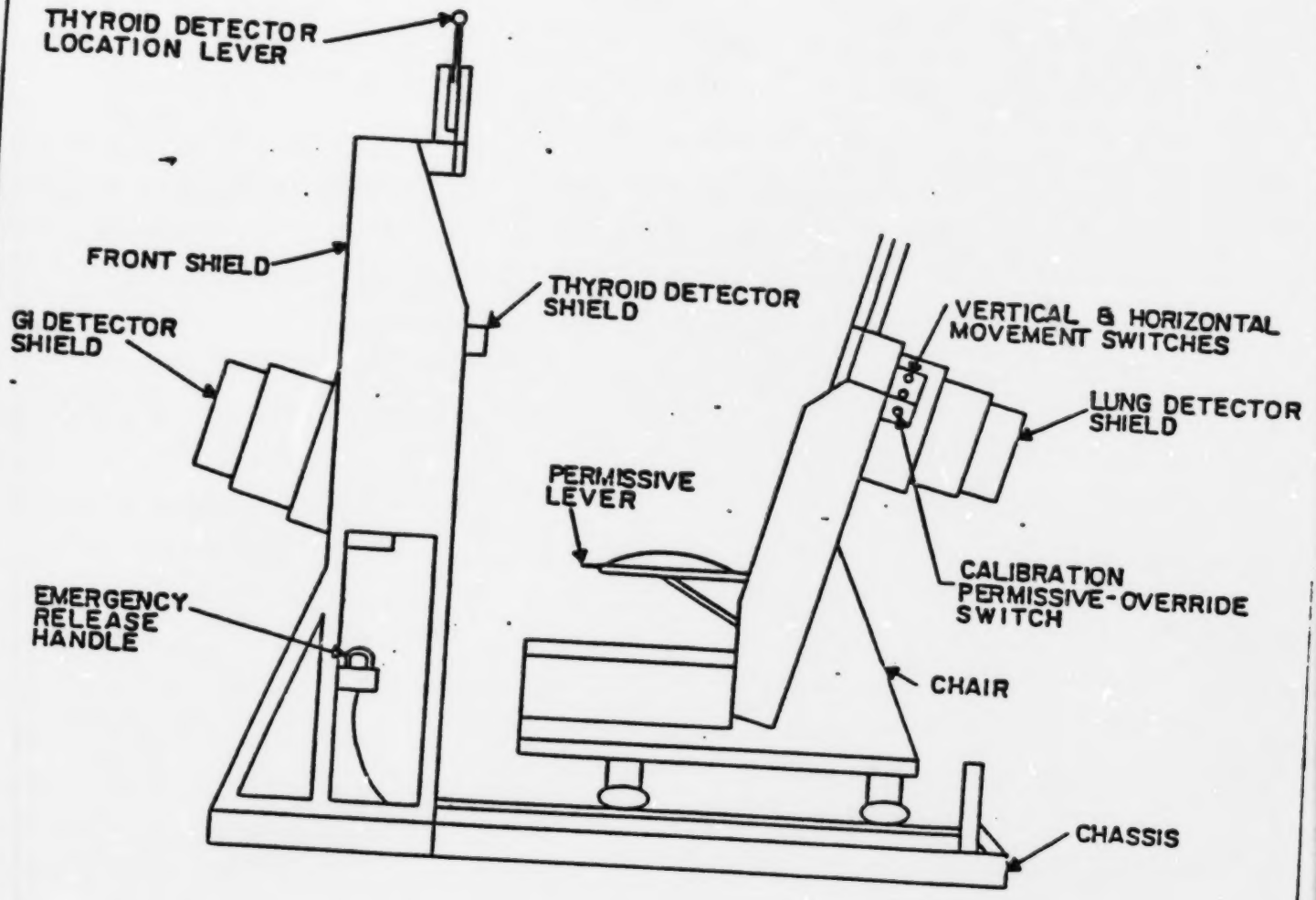


FIGURE 1 APT MODEL WBC6000 WHOLE BODY COUNTER

TABLE 2 LOWER LIMITS OF DETECTION

ISOTOPE	LOWER LIMIT OF DETECTION					
	LOWER TORSO		LUNG		THYROID	
	Bq	mSv*	Bq	mSv*	Bq	mSv*
Ce-144	5.3E03	5E0	3.1E03	3E0	N/A	
Cr-51	3.5E03	1E-2	2.0E03	8E-3	N/A	
Ba-140	1.0E03	7E-1	6.7E02	4E-1	N/A	
Cs-137	3.1E02	6E-2	1.8E02	3E-2	N/A	
Zr-95	4.1E02	5E-2	2.7E02	2E-2	N/A	
Cs-134	2.6E02	5E-2	1.7E02	3E-2	N/A	
Co-58	2.2E02	2E-2	1.4E02	7E-1	N/A	
Mn-54	2.2E02	9E-3	1.4E02	3E-3	N/A	
Fe-59	4.0E02	5E-2	2.6E02	1E-2	N/A	
Zn-65	4.6E02	1E-2	2.8E02	6E-3	N/A	
Co-60	2.1E02	4E-2	1.3E02	2E-2	N/A	
I-131	N/A		N/A		2.3E01	4E-2
I-133	N/A		N/A		2.1E01	7E-2

* Effective whole body dose equivalent (HE) received per annum if a constant level of internal contamination is maintained. at the lower limit of detection.

Data Sheet

1. General

1.4	Laboratory	RADIOPHYSIQUE
1.5	Address & Telephone Number	Centrale nucléaire Gentilly-CP360-Gentilly G0X 1G0
1.6	Head of Laboratory	FORTIN, Roland (298-2943 - ext:247)
1.7	Expert in Charge	CRETE, Louis
1.8	Main Uses	1. HUMANS (Natural Activity) 2. HUMANS (Artificial act.) NOTE: Nuclear Workers

2. Methods

2.1	Technique	S. SINGLE/INTERCHANGEABLE. DETECTOR LINEAR SCANNING TECHNIQUE
2.2	Geometries	C. TYPE/MODIFIED A=32 L=200 S=35.5

3. Monitoring Room

3.1	Location	BASEMENT
3.2a	Portable or Fixed	FIXED
3.3	Approximate Inside Dimensions (cm)	L=406 W=61 H=36.8
3.4	Inner Shielding	
.1	Material	LEADS
.3	Source of Material	VIRGIN LEADS
.4	Thickness	15 cm
.7	Inside Finish	VINYL WALL PAPER
.8	Entrance Type	OPEN SYSTEM
3.5	Outer Shielding	3 CONCRETE WALLS 30 cm THICKNESS
3.6	Ventilation System (yes or no)	YES COLLECTIVE
3.7	Heating/Cooling System (yes or no)	2 000 W ELECTRIC HEATER WHEN REQUIRED
3.8	Anti-claustrophobial Measures	RADIO, MUSIC, DOOR KEPT OPEN

4. Detectors

4.1	Detector Type	INa ENRICHED WITH THALLIUM	INTRINSIC GERMANIUM
4.2	Detector Number	1	2
4.3	Shape/Volume	CYLINDRICAL 20,3 cm DIAx10,2	CLOSED ENDED COAXIAL 60 cc
4.4	Shielding	10 cm LEAD	10 cm LEAD
4.5	Position of Detector	PATIENT IS MOVED BENEATH STATIONARY DETECTOR	

5. Basic Ancillary Equipment

5.4 Analyser	
Series Number	111408932
Number of Channels	2048
Manufacturer	NUCLEAR DATA INC.
Model	ND 6620
Type	COMPUTER

5.5 Read-out Units

	#1	#2	#3	#4
Unit Type (Chart Recorder or Computer Screen)	CRT	TYPE	RATE METER	RECORDER
Manufacturer	NUCLEAR DATA	DIGITAL	TENNELEC	YOKOGAWA
Model Code	ND 66	LA120	TC590	TYPE 3046

6.0 Illustrations (Optional)

7.0 Calibration Data
(See Annexed Sheet)

8.0 Minimal Detectable Activity
(Specify Radionuclides and Units) Cs^{137} $\mu Ci \times 10^{-3}$ DET #1: 3,8 DET #2: 17,3

9.0 Accuracy (% Error) DET # 1: 25% DET # 2: 10%

10.0 Type of Phathom used for Calibration 70 L: POLYETHYLENE PHANTOMS

11.0 Time Period of Examination (Minutes) 11,1 MINUTES

12.0 Frequency of Use 10 PER DAY

13.0 Estimated Cost of Whole Body Counter

14.0 Additional Comments

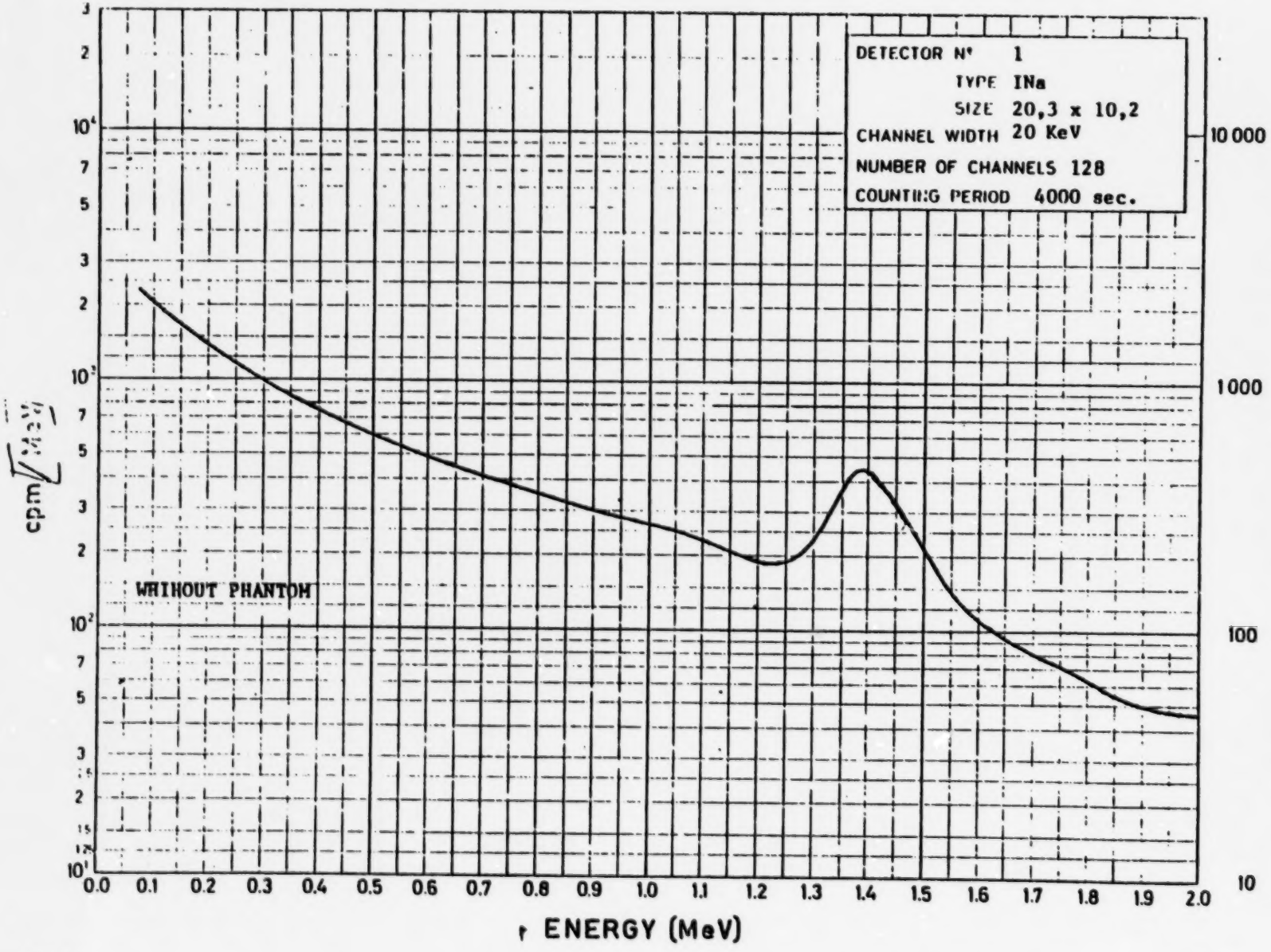
On a routine basis we do eleven minutes scanning. If any deviation from the normal spectrum occur, we do the sixty seven minutes scanning or fifteen minutes fix position over a particular region e.g. thyroid or stomach

7. CALIBRATION DATA

Detector/ Technique	Spectrometric resolution (in vivo)		Integral background	Radio-nuclide	Energy band				Net background	Net pulse rate	Contribution from **					
	K^{40}	Cs^{137}	(0.1 - 2.0 MeV)	**		Lower limit	Upper limit	Band-width			K^{40}	Cs^{137}				
(No)/ -	(%)	(%)	(cpm)	(.:)	(No.)	(MeV)	(MeV)	(MeV)	(cpm)	(cpm/μc)*	(cpm/gK)	(cpm/μc)	(cpm/μc)	(cpm/μc)	(cpm/μc)	(cpm/
1	7,5	10,9	973,4	^{137}Cs	1	0,540	0,740	0,20	101,5	3627						
				^{203}Hg	3	1,00	1,60	0,60	223,5	4710,0						
				^{131}I	4	0,26	0,40	0,14	137,9	4135,8						
				^{60}Co	5	1,24	1,42	0,18	56,0	2886						
				^{40}K	2	1,32	1,54	0,22	77,2	293,0	0,25					

* For all K^{40} readings, the units are cpm/gK

** For the radionuclide for which the monitor is calibrated, a footnote should be attached giving the calibration procedure. [e.g. (1) Point source 5 cm deep in a 40 cm × 40 cm × 20 polyethylene block. (2) Solution of radionuclide throughout 70 l phantom. (3) Solution of radionuclide in 10 l pipe system simulating skeleton in a 70 l phantom filled with distil water. (4) Calculated from measurements on human subjects after oral administration of (details of radioisotope). Material and manufacturer of the phantom, chemical form of rad nuclide, etc. also constitute valuable information.]



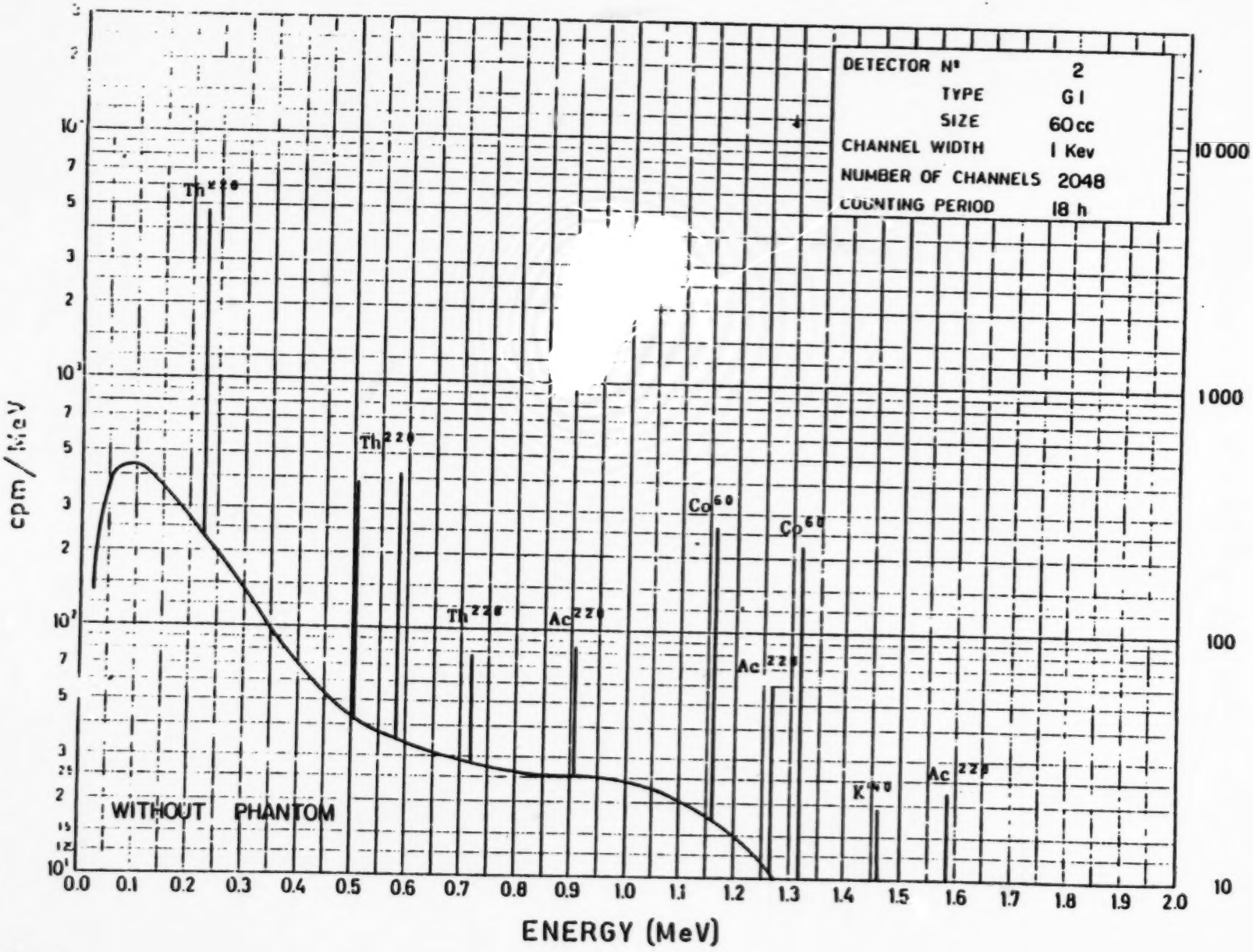
GRAPH OF BACKGROUND SPECTRUM

7. CALIBRATION DATA

Detector/ Technique	Spectrometric resolution (in vivo)		Integral background	Radio-nuclide	Energy band			Net background	Net pulse rate	Contribution from**					
	K^{40}	Cs^{137}	(0.1 - 2.0 MeV)	**		Lower limit	Upper limit	Band-width							I^{131} al
(No.)/ -	(%)	(%)	(cpm)		(No.)	(MeV)	(MeV)	(MeV)	(cpm)	(cpm/μc)*	(cpm/gK)	(cpm/μc)	(cpm/μc)	(cpm/μc)	(cpm/μc)	Ba^{13} (cpm/
2	0,27	0,38	149	^{137}Cs		0,655	0,666	0,011	0,4	676	-	676	0,2	2	-	58
				^{54}Mn		0,827	0,840	0,013	0,5	567	-	41	567	5	2	53
				^{60}Co		1,167	1,178	0,011	1,17	796	1	104	136	796	0,4	75
				^{40}K		1,453	1,466	0,013	0,1	4,2	0,003	0,6	0,7	1,1	4,2	1,.
				^{133}Ba		0,351	0,360	0,009	1	1647	-	-	0,8	1,1	-	164

* For all K^{40} readings, the units are cpm/gK

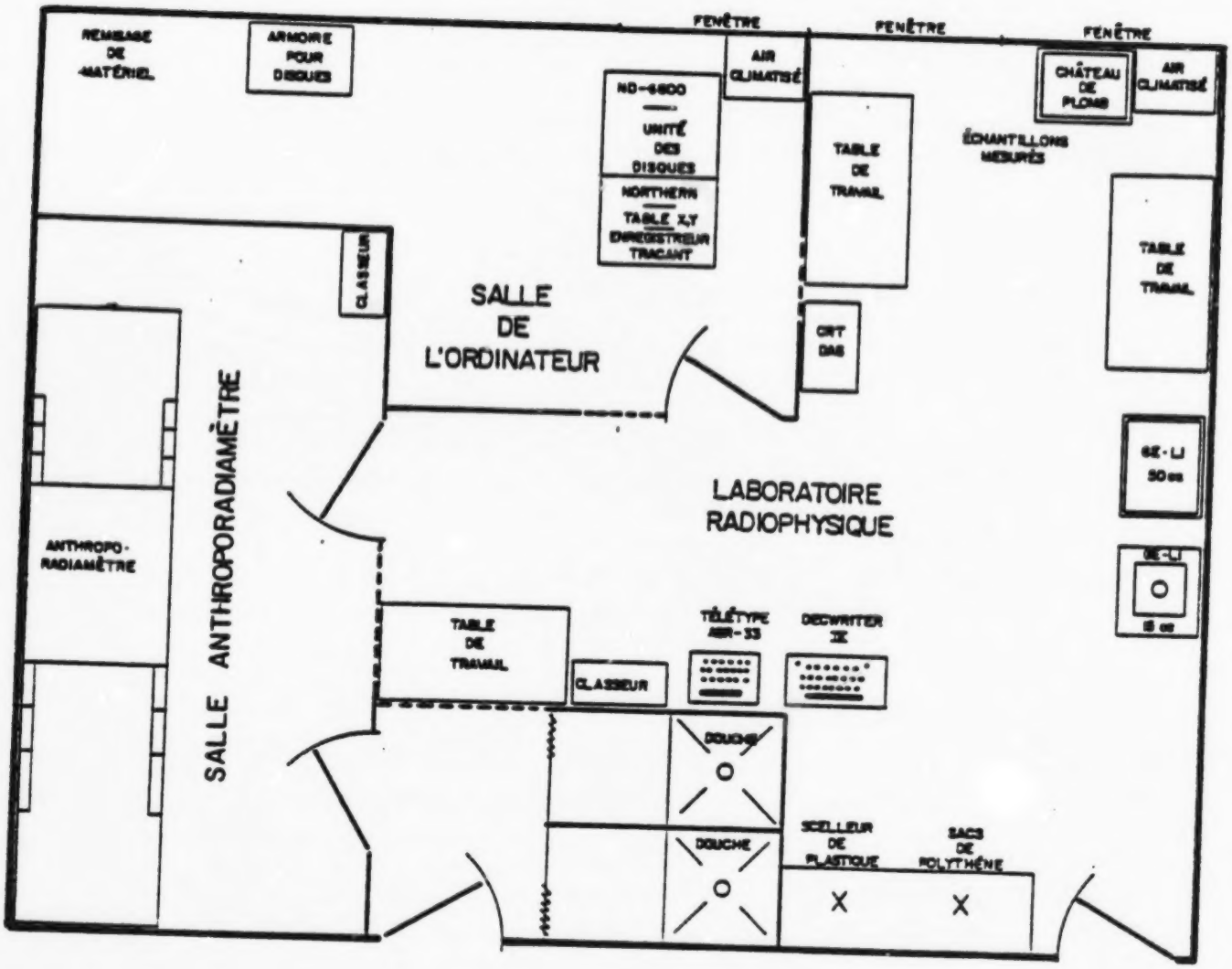
** For the radionuclide for which the monitor is calibrated, a footnote should be attached giving the calibration procedure. [e.g. (1) Point source 5 cm deep in a 40 cm × 40 cm × 20 polyethylene block. (2) Solution of radionuclide throughout 70 l phantom. (3) Solution of radionuclide in 10 l pipe system simulating skeleton in a 70 l phantom filled with distilled water. (4) Calculated from measurements on human subjects after oral administration of (details of radioisotope). Material and manufacturer of the phantom, chemical form of the nuclide, etc. also constitute valuable information.]



GRAPH OF BACKGROUND SPECTRUM

ANNEXE I

PLAN DU LABORATOIRE DE RADIOPHYSIQUE



Data Sheet

1. General

1.4	Laboratory	Safety Services Department
1.5	Address & Telephone Number	757 McKay Road (416)683-7516
1.6	Head of Laboratory	George J. Pilar
1.7	Expert in Charge	M. Pope
1.9	Main Uses	Humans (artificial activity)

2. Methods

2.1	Technique	Single detector linear scanning bed
2.2	Geometries	

3. Monitoring Room

3.1	Location	trailer - ground floor
3.2a	Portable or Fixed	portable
3.3	Approximate Inside Dimensions (cm)	L (759) W (212) H (225)
3.4	Inner Shielding	
.1	Material	lead
.3	Source of Material	virgin
.4	Thickness	5 cm
.7	Inside Finish	stainless steel
.8	Entrance Type	hinged door
3.5	Outer Shielding	None → walls of trailer
3.6	Ventilation System (yes or no)	Yes
3.7	Heating/Cooling System (yes or no)	Yes
3.8	Anti-claustrophobial Measures	(music & magazines available)

4. Detectors

4.1	Detector Type	NaI (Tl)
4.2	Detector Number	single crystal
4.3	Shape/Volume	8" x 4" volume 200 cu inches
4.4	Shielding	10 cm of virgin lead
4.5	Position of Detector	stainless steel canning suspended above counting bed.

5. Basic Ancillary Equipment

5.4 Analyser

Series Number	60
Number of Channels	256
Manufacturer	Nuclear Data
Model	ND60
Type	Microprocessor

5.5	Read-out Units		
	Unit Type (Chart Recorder or Computer Screen)	video screen	thermal printer magnetic tape
	Manufacturer	Nuclear Data	Texas Instruments
	Model Code	ND60	Silent 700

6.0 Illustrations (Optional)

7.0 Calibration Data (See Annexed Sheet)

N/A - use modified Alpha M program for peak search etc.

8.0 Minimal Detectable Activity (Specify Radionuclides and Units)

see attachment

9.0 Accuracy (% Error)

Cs-137 @ 100 nCi ± 3%
Co-60 @ 50-100 nCi ± 5%
K-40 @ 100 nCi ± 23%

10.0 Type of Phathom used for Calibration

Grey and Marten water filled polyethylene phantom

11.0 Time Period of Examination (Minutes)

6 to 7

12.0 Frequency of Use

annually

13.0 Estimated Cost of Whole Body Counter

Present book value $25,000.00

14.0 Additional Comments

- As of 1980 our calibration consists of complete library spectra for about 9 nuclides.

- The analysis program compares the unknown spectra to selected library spectra.

- The calibration data you request is available for 1977, the last calibration performed this way.

title: 1.0 OUTLINE OF WHOLE-BODY COUNTING

TABLE 1.0

Minimum Detectable Activities for Selected Radionuclides

Radionuclide	Minimum Detectable Activity		MPBB	MDA % Fraction of MPBB	Critical Organ
^{137}Cs	220 Bq	(6 nCi)	1100 kBq (30 uCi)	0.02%	Whole-body
^{134}Cs	185 Bq	(6 nCi)	740 kBq (20 uCi)	0.02%	Whole-body
^{60}Co	150 Bq	(4 nCi)	370 kBq (10 uCi)	0.04%	Whole-body
			40 kBq (1.1 uCi)	0.04%	Lung
^{131}I	260 Bq	(7 nCi)	26 kBq (0.7 uCi)	1.0%	Thyroid
^{106}Ru	920 Bq	(25 nCi)	110 kBq (3 uCi)	0.8%	Kidney
			22 kBq (0.6 uCi)	4.0%	Lung
^{95}Zr	75 Bq	(2 nCi)	740 kBq (20 uCi)	0.01%	Whole-body
			60 kBq (1.6 uCi)	0.1%	Lung
^{140}Ba	110 Bq	(3 nCi)	150 kBq (4 uCi)	0.07%	Bone
			22 kBq (0.6 uCi)	0.5%	Lung
^{65}Zn	300 Bq	(8 nCi)	2200 kBq (60 uCi)	0.01%	Whole-body
			210 kBq (5.6 uCi)	0.1%	Lung
^{144}Ce	2220 Bq	(60 nCi)	185 kBq (5 uCi)	1.2%	Bone
			22 kBq (0.6 uCi)	10.0%	Lung

* The MPBB and the corresponding Critical Organ are dependent on the transportability of the radionuclide.

INTERIOR LAYOUT OF THE MOBILE WHOLE-BODY COUNTER LABORATORY

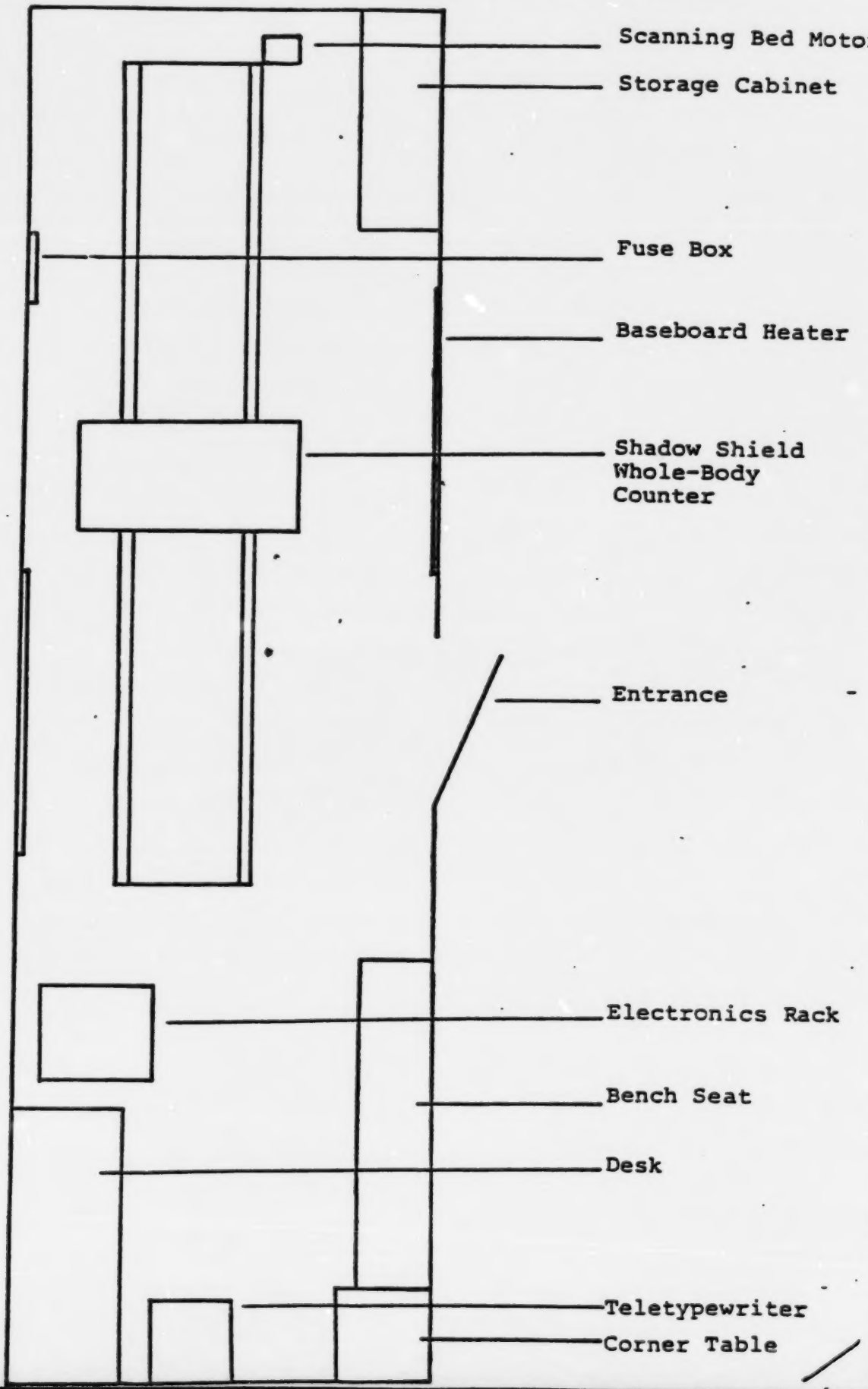
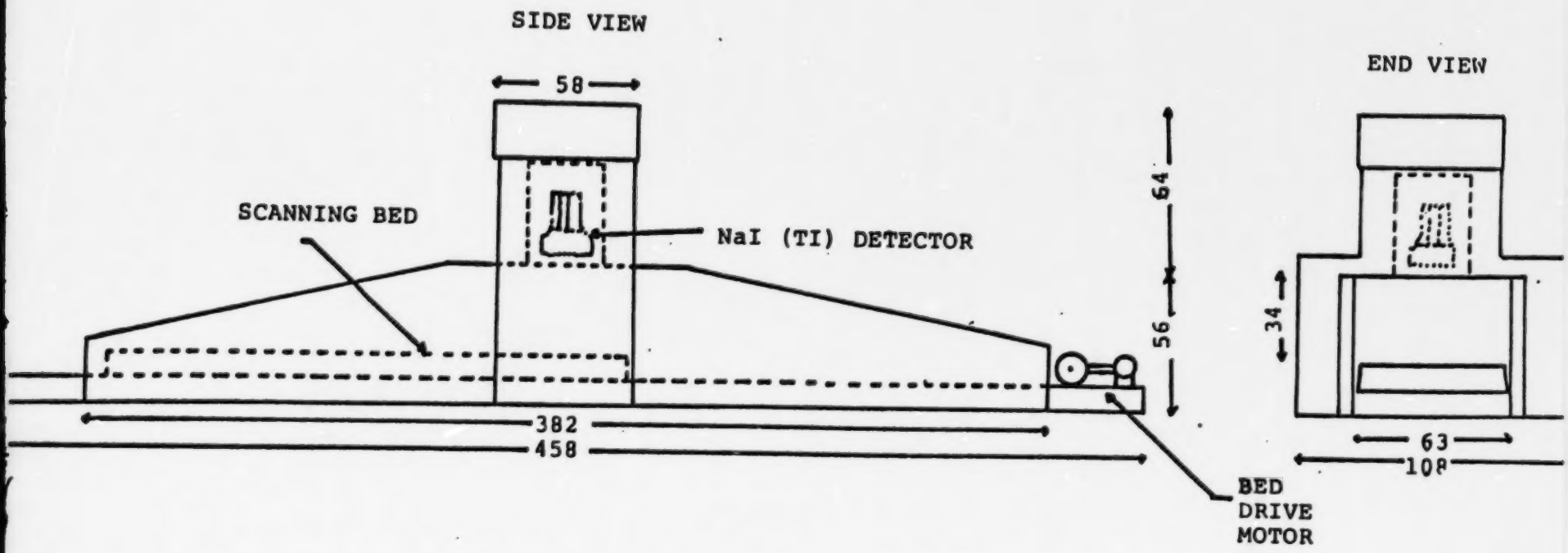


FIGURE 2.2

THE SHADOW SHIELD WHOLE-BODY COUNTER



All dimensions are in cm.

TABLE C. TYPICAL BLANK CALIBRATION DATA FORM AS SENT OUT TO LABORATORIES

7. CALIBRATION DATA

Detector/ Technique	Spectrometric resolution (in vivo)		Integral background	Radionuclide	Energy band				Net background	Net pulse rate	Contribution from **					
	K^{40}	Cs^{137}	(0.1 - MeV)	**	(No.)	Lower limit (MeV)	Upper limit (MeV)	Band-width (MeV)			K^{40}	Cs^{137}				
(NaI)/-	(%)	(%)	(cpm)						(cpm)	(cpm/pc)*	(cpm/gK)	(cpm/pc)	(cpm/pc)	(cpm/pc)	(cpm/pc)	(cpm/pc)
		7.4														

PART I

* For all K^{40} readings, the units are cpm/gK.

** For the radionuclide for which the monitor is calibrated, a footnote should be attached giving the calibration procedure (e.g. (1) Point source 5 cm deep in a 40 cm × 40 cm × 20 cm polyethylene block. (2) Solution of radionuclide throughout 70 l phantom. (3) Solution of radionuclide in 10 l pipe system simulating skeleton in a 70 l phantom filled with distilled water. (4) Calculated from measurements on human subjects after oral administration of (details of radioisotope). Material and manufacturer of the phantom, chemical form of radionuclide, etc. also constitute valuable information.)

Data Sheet

1. General

1.4	Laboratory	Human Monitoring Laboratory, BRMD-NHW
1.5	Address & Telephone Number	775 Brookfield Rd. Ottawa, Ontario. 998-9715
1.6	Head of Laboratory	Dr. E. Létourneau
1.7	Expert in Charge	Dr. M. Limson-Zamora
1.8	Main Uses	1. Humans (natural activity): 1,2,4,5,6 2. Humans (artificial activity): 1,3,5 3. Animals: 3 4. Physical studies: 2,3

2. Methods

2.1	Technique	E. Multidetector stretcher technique
2.2	Geometries	See annex

3. Monitoring Room

3.1	Location	Ground level
3.2a	Portable or Fixed	fixed
3.3	Approximate Inside Dimensions (cm)	L-213, H-213, W-152
3.4	Inner Shielding	
	.1 Material	Steel
	.3 Source of Material	old naval steel
	.4 Thickness	a total of 20 cm
	.7 Inside Finish	epoxy paint over lead lining
	.8 Entrance Type	pneumatic driven hinged doors
3.5	Outer Shielding	none
3.6	Ventilation System (yes or no)	Air conditioned building
3.7	Heating/Cooling System (yes or no)	Air center med building set at 70°F
3.8	Anti-claustrophobial Measures	radio, music, intercom, 2 feet thick wate filled window

2. Form of mat.: 2 slabs of steel each of which is 1" thick

4. Detectors

4.1	Detector Type	chamber #1: 2 phoswich, #2: 5 sodium iodide
4.2	Detector Number	chamber #1: 1&2; chamber #2 numbered 1 to 5
4.3	Shape/Volume	ch. #1:15 cm. diameter cylinder 0.3 cmNaI plus 5 cm Cs I; ch #2: cylindrical 10 cm di
4.4	Shielding - None	
4.5	Position of Detector - chamber #1:	angled (moveable) 13 cm th
	chamber #2:	vertical

5. Basic Ancillary Equipment

5.4 Analyser

Series Number	Canberra Series 90 MCA
Number of Channels	16K channels interfaced with
Manufacturer	Digital Equipment PDP 1144 computer
Model	with LA120 printer
Type	and Hewlett Packard 7225A plotter

5.5 Read-out Units
Unit Type (Chart Recorder or Computer Screen)
Manufacturer
Model Code

6.0 Illustrations (Optional)

7.0 Calibration Data
(See Annexed Sheet)

8.0 Minimal Detectable Activity (Specify Radionuclides and Units)

Cs^{137} 0.60 nCi
K^{40} 5 grams Nat U. 3 mg.

9.0 Accuracy (% Error)

Cs^{137} 10%
K^{40} 4% Nat U ±(2 mg + 10%

10.0 Type of Phantom used for Calibration

i) Lawrence Livermore Lab. Realistic Thora Phantom
ii) BOMAB phantom
iii) Open box phantom

11.0 Time Period of Examination (Minutes)

30 minutes

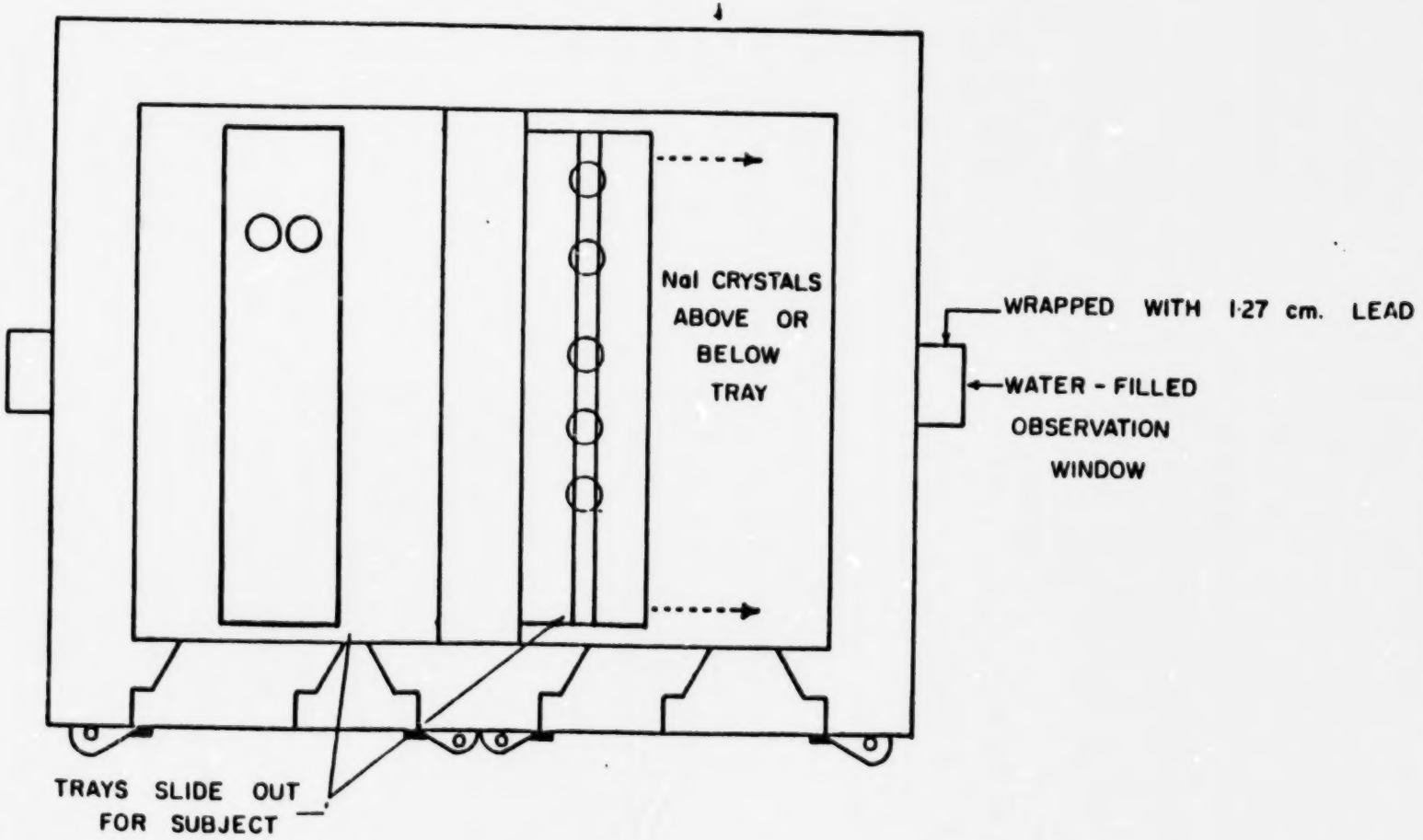
12.0 Frequency of Use

variable, up to 6 subjects a day

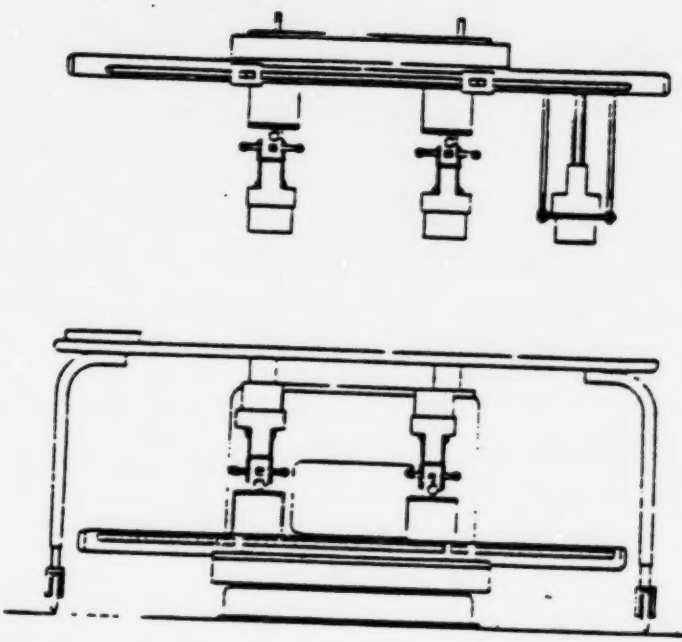
13.0 Estimated Cost of Whole Body Counter

14.0 Additional Comments

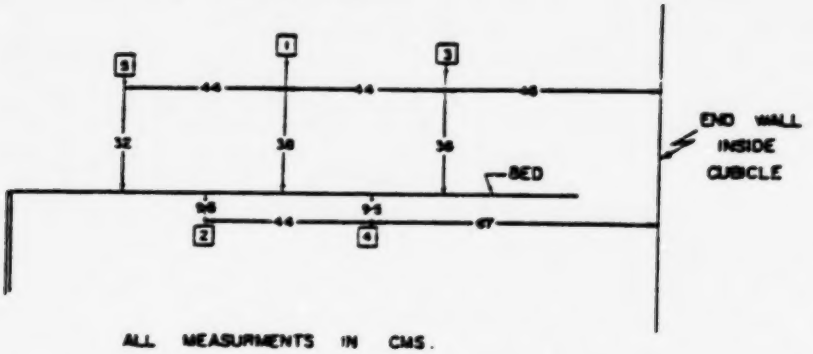
Hyperpure germanium detectors are being designed and built for this facility. So far, BRMD has received only two of a set of 4 hyperpure Ge detectors and no data on this equipment is available as yet.



PLAN OF MONITORING ROOMS SHOWING DETECTOR POSITIONS



"G" GEOMETRY —



ALL MEASURMENTS IN CMS.

Data Sheet

1. General

1.4	Laboratory	CRNL
1.5	Address & Telephone Number	(613) 584-3311
1.6	Head of Laboratory	J.R. Johnson
1.7	Expert in Charge	G. Kramer/J. Johnson
1.8	Main Uses	Monitoring Employees

2. Methods

2.1	Technique	Shadow Shield
2.2	Geometries	Scanning bed

3. Monitoring Room

3.1	Location	CRNL Bldg 560
3.2a	Portable or Fixed	Fixed
3.3	Approximate Inside Dimensions (cm)	See 2 above
3.4	Inner Shielding	
.1	Material	Pb - Fe
.3	Source of Material	CRNL
.4	Thickness	Varies
.7	Inside Finish	Smooth
.8	Entrance Type	See 2 above
3.5	Outer Shielding	Partial
3.6	Ventilation System (yes or no)	Yes
3.7	Heating/Cooling System (yes or no)	Yes/Yes
3.8	Anti-claustrophobial Measures	Music

4. Detectors

4.1	Detector Type	$NaI_{(Tl)}$ $1\frac{1}{2}$" X 4"
4.2	Detector Number	1
4.3	Shape/Volume	See 2 above
4.4	Shielding	"
4.5	Position of Detector	"

5. Basic Ancillary Equipment

5.4 Analyser

Series Number	
Number of Channels	Computer based MCA
Manufacturer	
Model	
Type	

5.5 Read-out Units

Unit Type (Chart Recorder or Computer Screen)

Manufacturer

Model Code

- Computer screen, printer, disk, mag tube

6.0 Illustrations (Optional)

7.0 Calibration Data
(See Annexed Sheet)

8.0 Minimal Detectable Activity
(Specify Radionuclides and Units)

Varies with radionuclide and subject

9.0 Accuracy (% Error)

Varies with radionuclide and subject

10.0 Type of Phathom used for Calibration

Bottle and others

11.0 Time Period of Examination (Minutes)

average of 20 minutes

12.0 Frequency of Use

Continuous (8-10 people a day)
(15-20000 people/a)

13.0 Estimated Cost of Whole Body Counter

$400,000 (Low background building incl.)

14.0 Additional Comments

System is described in AECL documents CRNL-2582 and CRNL-2648

Data Sheet

1. General

1.4	Laboratory	Department of Nuclear Medicine
1.5	Address & Telephone Number	McMaster University Med. Centre, Hamilton, Ont
1.6	Head of Laboratory	Dr. E.S. Garnett
1.7	Expert in Charge	Dr. C.E. Webber
1.8	Main Uses	Natural and man-made ~~radioactivity (Humans)~~ Physics studies (background and WB methods)

2. Methods

2.1	Technique	linear scanning
2.2	Geometries	

3. Monitoring Room

3.1	Location	Ground Floor
3.2a	Portable or Fixed	Fixed
3.3	Approximate Inside Dimensions (cm)	
3.4	Inner Shielding	
.1	Material	Lead
.3	Source of Material	Virgin Lead
.4	Thickness	Variable from 1" to 6"
.7	Inside Finish	Either Cd-Cu covered or Pb exposed
.8	Entrance Type	Shadow Shield
3.5	Outer Shielding	None
3.6	Ventilation System (yes or no)	No
3.7	Heating/Cooling System (yes or no)	No
3.8	Anti-claustrophobial Measures	Not required as shown by 11 years of use of our Shadow Shield System

4. Detectors

4.1	Detector Type	NaI (Tl)
4.2	Detector Number	1
4.3	Shape/Volume	11" x 4" rectangular cylinder
4.4	Shielding	Up to 6" Lead
4.5	Position of Detector	Above moving couch

5. Basic Ancillary Equipment

5.4	Analyser	
	Series Number	MCA based on PDP 11/03 Computer
	Number of Channels	1024
	Manufacturer	home built
	Model	
	Type	

5.5 Read-out Units

Unit Type (Chart Recorder or Computer Screen): CRT and Floppy disc

Manufacturer:

Model Code:

6.0 Illustrations (Optional)

7.0 Calibration Data (See Annexed Sheet): Energy Resolution: $FWHM(\%) = 3.57 + (151.56 \times E^{-\frac{1}{2}})$ where E is photon energy.

8.0 Minimal Detectable Activity (Specify Radionuclides and Units): For ^{40}K measurement in typical patient, background is 200 cpm in an energy region of 1300 - 1630 KeV

^{238}U — 6 mg in lung

9.0 Accuracy (% Error): ± 6% for total body potassium

10.0 Type of Phathom used for Calibration: KCl water filled bottles

11.0 Time Period of Examination (Minutes): ^{40}K — 40 mins.

12.0 Frequency of Use: 2 -3 per week

13.0 Estimated Cost of Whole Body Counter: $24,000 in 1972

14.0 Additional Comments: Our major applications are clinical and health physics. The former uses are mainly ^{40}K measurements. The latter are extremely variable. We have made measurements of uranium in the lungs of miners; ^{110m}Ag in reactor workers, ^{99}Mo - ^{99m}Tc in radiopharmacists, ^{103}Ru in a graduate student and many others.

Data Sheet

1. General

1.4	Laboratory	Eldorado Resources Limited
1.5	Address & Telephone Number	1 Eldorado Place, Port Hope, Ont. 416-885-4511
1.6	Head of Laboratory	H. Carisse Superintendent of Compliance & Li
1.7	Expert in Charge	S. Allen Lung counter technologist
1.8	Main Uses	Humans (artificial Activity) Thorax Burdens - Uranium

2. Methods

2.1	Technique	Multiple Detector - Fixed Position - Stretche
2.2	Geometries	Attached Illustration 6.2

3. Monitoring Room

3.1	Location	Port Hope Facility 1 Eldorado Place
3.2a	Portable or Fixed	Portable (40 foot trailer)
3.3	Approximate Inside Dimensions (cm)	213 cm, 76cm, 132cm
3.4	Inner Shielding	
.1	Material	Steel
.3	Source of Material	Selected Low Background Level Material
.4	Thickness	10.2 cm
.7	Inside Finish	"Mac-Tac" vinyl & clear laquer
.8	Entrance Type	Hinged Door
3.5	Outer Shielding	
3.6	Ventilation System (yes or no)	Yes
3.7	Heating/Cooling System (yes or no)	Yes
3.8	Anti-claustrophobial Measures	Lights, Music, Intercom, Window, Ventilation

4. Detectors

4.1	Detector Type	Phoswich - NaI(TI)/CsI Backed
4.2	Detector Number	Four
4.3	Shape/Volume	12.7 cm dia. x 6.4 cm thickness (see note)
4.4	Shielding	none
4.5	Position of Detector	see attached illustration 6.2

Note: (1.25 cm NaI + 5.0 cm CsI)

5. Basic Ancillary Equipment

5.4	Analyser	
	Series Number	35
	Number of Channels	1024
	Manufacturer	Canberra
	Model	35
	Type	Transistor

5.5	Read-out Units Unit Type (Chart Recorder or Computer Screen) Manufacturer Model Code	Computer Screen (Canberra Series 35) Plus LA 50 printer - digital equipment Corporation
6.0	Illustrations (Optional)	
7.0	Calibration Data (See Annexed Sheet)	**
8.0	Minimal Detectable Activity (Specify Radionuclides and Units)	5 mgU(U235) 3 mgU(U238/Th234)
9.0	Accuracy (% Error)	*
10.0	Type of Phathom used for Calibration	Original - Remcal- RadiationManagement Corp Yearly - Lawrence Livermore - RPB - Ottaw
11.0	Time Period of Examination (Minutes)	Thirty (30)
12.0	Frequency of Use	Daily - Routine monitoring
13.0	Estimated Cost of Whole Body Counter	$140,000 U.S. - 1978
14.0	Additional Comments	*Using a standard 50 mgU plane source inside a "plastic chest" of fixed dimensions the accuracy is 1. for U235 - 50.8 ± 6.9 mgU. 2. for U238 (Th234) 56.2 ± 2.3 mgU ** Original Calibration by RMC - Chicago Yearly performance checks by RPB-Ottawa. Daily check sources run for detector adjustment and calibration verification.

LUNG COUNTING FACILITY

40' TRAILER

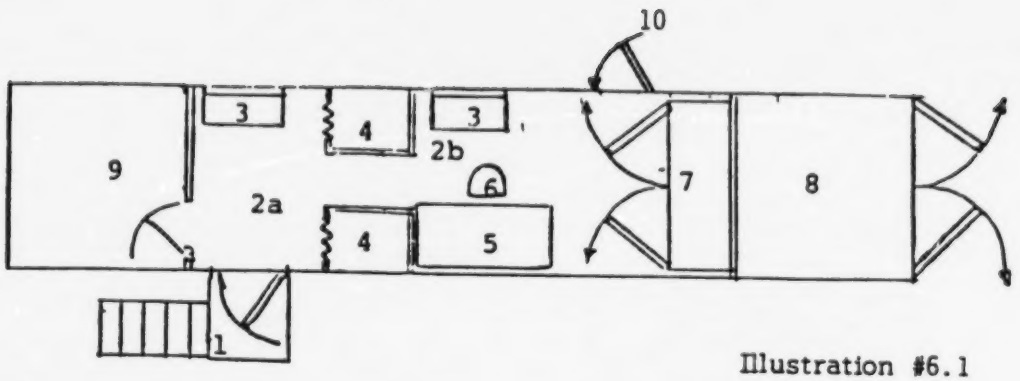


Illustration #6.1

1. Removable entry platform and steps.

2a. Waiting area - street clothing.

2b. Clean area - operator and gowned personnel only.

3. Bench (2 each) storage under seat.

4. Change rooms - with mirror, bench, light, clothes hangers

5. Equipment console
   Optima table top console with electronic rack underneath,
   Table top computer, all to be shock mounted for protection.

6. Operators chair.

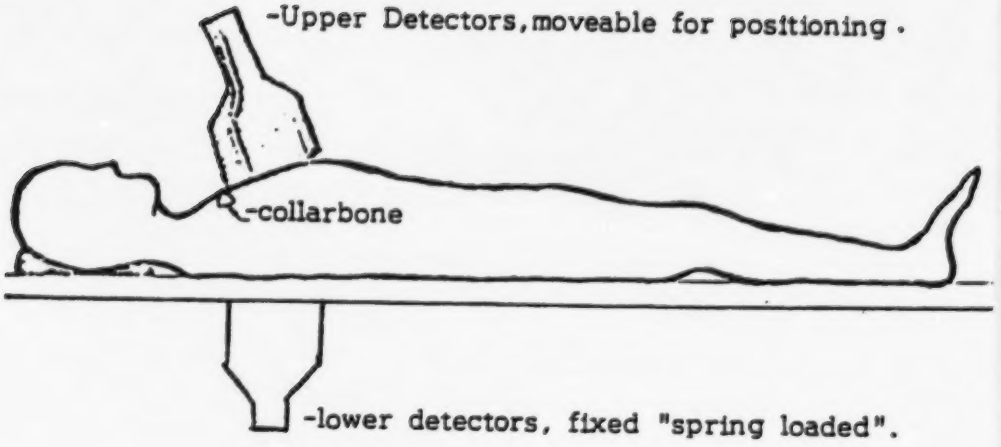
7. Shield.

8. Mechanical equipment/storage room. Contains central heating and air conditioning system, electrical connections, storage for stairs and platform, land power hook-up cable, etc.

9. Office area.

10. Emergency Exit

DETECTOR POSITIONING



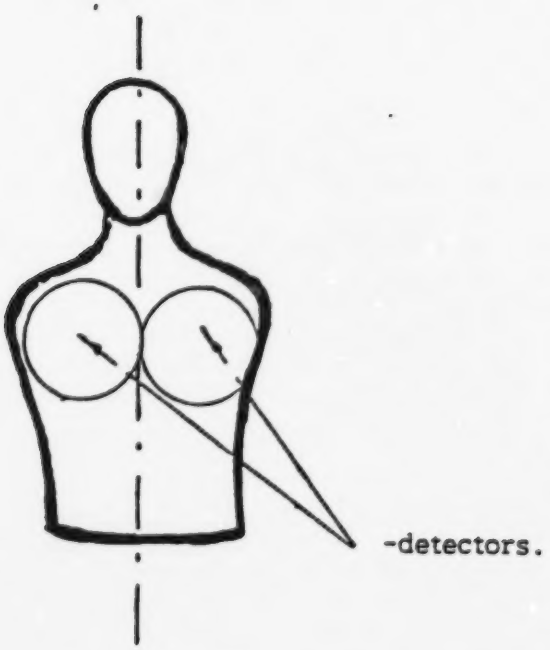


Illustration #6.2

Data Sheet

1. General

1.4	Laboratory	Medical Physics Lab, Toronto Gen. Hc
1.5	Address & Telephone Number Room	CCRW-G-803, 200 Elisabeth St, ont. 595-404
1.6	Head of Laboratory	Dr. J.E. Harrison M5G 2C4
1.7	Expert in Charge	Dr. S.S. Krishnan
1.8	Main Uses	in vivo measurements eg. Ca, N measurements of K-40, I-125 and other health physics measurements

2. Methods

2.1	Technique	4 detectors on stretcher (8"x5" NaI)
2.2	Geometries	60 cm shoulder to thigh, also can sca

3. Monitoring Room

3.1	Location	Basement
3.2a	Portable or Fixed	Fixed
3.3	Approximate Inside Dimensions (cm)	ht. 240 cm
		Width 143 cm
		Length 245 cm
3.4	Inner Shielding	
.1	Material	Low background steel
.3	Source of Material	
.4	Thickness	
.7	Inside Finish	
.8	Entrance Type	
3.5	Outer Shielding	
3.6	Ventilation System (yes or no)	Recirculated air from laboratory
3.7	Heating/Cooling System (yes or no)	Central air conditioning
3.8	Anti-claustrophobial Measures	Intercom, close circuit tv, door may be kept oper sometimes.

4. Detectors

4.1	Detector Type	NaI
4.2	Detector Number	4
4.3	Shape/Volume	Cylindical 20 cm dia/extruded 4x4x16"
4.4	Shielding	
4.5	Position of Detector	Above (2) and below (2) to stretcher.

5. Basic Ancillary Equipment

5.4	Analyser	
	Series Number	
	Number of Channels	1024
	Manufacturer	Canberra
	Model	8100
	Type	

5.5 Read-out Units

Unit Type (Chart Recorder or Computer Screen): Teletype

Manufacturer

Model Code: Model 43

6.0 Illustrations (Optional)

7.0 Calibration Data
(See Annexed Sheet)

8.0 Minimal Detectable Activity
(Specify Radionuclides and Units): 1 to 5 nanocurie

9.0 Accuracy (% Error): Approximately 4%

10.0 Type of Phathom used for Calibration: Flat bed of KCl

11.0 Time Period of Examination (Minutes): Various

12.0 Frequency of Use: Daily average, almost 8 hrs. per da

13.0 Estimated Cost of Whole Body Counter

14.0 Additional Comments

Data Sheet

1. General

1.4	Laboratory	Whiteshell Nuclear Res. Est.
1.5	Address & Telephone Number	Pinawa, Man. 753-2311
1.6	Head of Laboratory	A. Petkau
1.7	Expert in Charge	S.D. Pleskach
1.8	Main Uses	1. Humans (natural activity) 2. Humans (artificial activity) 4. Food samples, etc.

2. Methods

2.1	Technique	see attached sheet
2.2	Geometries	

3. Monitoring Room

3.1	Location	ground floor
3.2a	Portable or Fixed	fixed
3.3	Approximate Inside Dimensions (cm)	L-244, W-183, H-244
3.4	Inner Shielding	
.1	Material	iron
.3	Source of Material	old naval steel
.4	Thickness	15.2 cm
.7	Inside Finish	none
.8	Entrance Type	hand-operated, hinged doors
3.5	Outer Shielding	none (other than building itself)
3.6	Ventilation System (yes or no)	yes
3.7	Heating/Cooling System (yes or no)	yes
3.8	Anti-claustrophobial Measures	intercom, music

4. Detectors

4.1	Detector Type	See attached sheet
4.2	Detector Number	
4.3	Shape/Volume	
4.4	Shielding	
4.5	Position of Detector	

5. Basic Ancillary Equipment

5.4	Analyser	
	Series Number	EB-5392
	Number of Channels	512
	Manufacturer	AECL
	Model	AEP-6002
	Type	Transistor

5.5 Read-out Units
Unit Type (Chart Recorder or Computer Screen)
Manufacturer
Model Code

See attached sheet

6.0 Illustrations (Optional)

7.0 Calibration Data
(See Annexed Sheet)

8.0 Minimal Detectable Activity
(Specify Radionuclides and Units) 0.75 nCi for Cs^{137}

9.0 Accuracy (% Error) 2.8% for K^{40}

10.0 Type of Phathom used for Calibration

Remcal

11.0 Time Period of Examination
(Minutes)

25 min.

12.0 Frequency of Use

daily

13.0 Estimated Cost of Whole Body Counter

14.0 Additional Comments

2. Methods

2.1 Technique

: single-detector chair (B)
: single-detector arc (A)
: multidetector linear scanning (C)
: two five-inch diameter phoswich detectors. Subject lies prone on the stretcher with detectors situated over the lungs.

2.2 Geometres

: B $a = 42$ cm, $b = 42$ cm, $c =$ zero
$d = 59$ cm, $\alpha = 45^{o}$, $\beta = 45^{o}$
$\gamma = 90^{o}$ $\delta =$ zero
Hands on arm rest

: A $\rho = 1$ meter

: C $L = 184$ cm
$A = 23$ cm
$S = 35$ cm

4.	Detectors			
4.1	Detector Type	NaI(Tl)	NaI(Tl)	Phoswich
4.2	Detector Number	1	2-4	5-6
4.3	Shape/Volume	: cylindrical 29.2-cm diam. X 10.2 cm	: cylindrical 5.1 cm diam. X 5.1 cm	: cylindrical 27.7 cm diam. X 3 mm NaI(Tl) 5 cm CsI(Tl)
4.4	Shielding	anti-magnetic	low background lead for collimation	anti-magnetic
4.5	Position of Detector	w-chair arrangement	scans over subject lying prone on stretcher	stationary over the lungs of a subject lying prone on a stretcher

5.5 Read-out units

Unit Type	tape-reader/ tapepunch printer	Chart Recorder	X-Y Plotter	Oscilloscope
Manufacturer	Teletype	Esterline Angus	HP	Fluke
Model	ASR33	E1124E	2D2	412B

7. CALIBRATION DATA

Detector/ Technique	Spectrometric resolution (in vivo)		Integral background	Radio-nuclide	Energy band				Net background	Net pulse rate	Contribution from	
	K^{40}	Cs^{137}	0.1-2 MeV			Lower limit	Upper limit	Band-width			K^{40}	Cs^{137}
(No.)/-	(%)	(%)	(cpm)		(No.)	(MeV)	(MeV)	(MeV)	(cpm)	(cpm/μc)*	(cpm/gK)	(cpm/μc)
1/B	7.8[a]	10.8[a]	2415	K^{40} [a]	1	1.36	1.55	0.19	170	1.36*	--	
				Cs^{137} [a]	1	0.61	0.71	0.10	170	17.7×10^3	0.23	--

* For all K^{40} readings, the units are cpm/gK

[a] Solution of radionuclide throughout Remical phantom, 70 kg, height - 1.73m

Data Sheet

1. General

1.4	Laboratory	Cancer Treatment Foundation, Medical Physics
1.5	Address & Telephone Number	100 Olivia St. Winnipeg
1.6	Head of Laboratory	N/A
1.7	Expert in Charge	Dr. Palser
1.8	Main Uses	1) Research purposes. 2) Bio distribution data for dosimetry 3) Nuclear Medicine studies

2. Methods

2.1	Technique	Bones radio pharmaceutical
2.2	Geometries	Double detector scanning bed

3. Monitoring Room

3.1	Location	
3.2a	Portable or Fixed	Fixed
3.3	Approximate Inside Dimensions (cm)	
3.4	Inner Shielding	
.1	Material	Concrete - Lead
.3	Source of Material	
.4	Thickness	
.7	Inside Finish	
.8	Entrance Type	
3.5	Outer Shielding	
3.6	Ventilation System (yes or no)	Yes
3.7	Heating/Cooling System (yes or no)	Yes
3.8	Anti-claustrophobial Measures	No (spacious)

4. Detectors

4.1	Detector Type	NaI (Tl)
4.2	Detector Number	2
4.3	Shape/Volume	(3" x 3") one above, one below
4.4	Shielding	
4.5	Position of Detector	

5. Basic Ancillary Equipment

5.4	Analyser	
	Series Number	Analog 5
	Number of Channels	
	Manufacturer	~~MDS Mathematical~~
	Model	
	Type	A square computer for commercial and home development.

5.5 Read-out Units

Unit Type (Chart Recorder or Computer Screen): Both

Manufacturer

Model Code

6.0 Illustrations (Optional)

7.0 Calibration Data
(See Annexed Sheet)

8.0 Minimal Detectable Activity (Specify Radionuclides and Units): ($Tc\text{-}99_m$; I-131; Ga67) 15 nCi

9.0 Accuracy (% Error): To be ascertained: 10-20%

10.0 Type of Phathom used for Calibration: Geometric mean

11.0 Time Period of Examination (Minutes)

12.0 Frequency of Use: Will process 2-3 persons/d

13.0 Estimated Cost of Whole Body Counter: Approximately $100K

14.0 Additional Comments